# APPENDIX D

# STUDY OF SAND BYPASSING OPTIONS AT CAPE MAY INLET, NEW JERSEY

D-1. Introduction. This appendix is meant to serve as a short example of the coastal processes engineering and economic analysis needed for a bypassing project. The text and figures are, for the most part, taken directly from the US Army Engineer District (USAED), Philadelphia, report "A Study of Sand Bypassing Options at Cape May Inlet, New Jersey" (USAED, Philadelphia 1987). This report provides a good example of effective coastal process analysis using dredging records. The economic analysis associated with a bypass project are also well done.

## Section I. Introduction

D-2. General. This report develops a preliminary design of a sand bypass plant using jet pumps and the cost of implementing said plant. It presents a least cost and operational comparison of the sand bypass option versus the approved plan for periodic nourishment by dredging for the Cape May Inlet to Lower Township project, and presents benefits attributable to reduced maintenance of the Federal navigation project at Cape May Inlet, New Jersey. Due to a shoreline retreat rate of around 10 feet per year, the bypassing problem can be considered a beach erosion problem. Political controversy exists (as with many bypassing projects) with implementing the Federal project fronting the city of Cape May. Although the problem has been approached as a beach nourishment problem, actual benefits and bypassing details have not been concluded at this time. However, the Cape May Inlet Project investigation serves as a good example towards developing a bypassing system plan for a given project.

D-3. Recommended Project Description. The recommended Cape May Inlet to Lower Township Project consists of improvements for beach fill, two new groins, maintenance of the two new and seven existing groins, periodic beach nourishment obtained from a deposition basin located on the northeast side of the inlet, a shoreline monitoring program for Lower Township, and a weir breakwater at Cape May Inlet with construction being deferred pending demonstration of need. Material for initial beach fill will be obtained from an offshore borrow area. The estimated total cost is $18.4 million (October 1986 base). The recommended plan for Cape May City would modify the Cape May Inlet Navigation Project by providing, where applicable, for measures to mitigate shore damages attributable to the inlet jetties in accordance with Section 111 of the River and Harbor Act of 1968. The plan recommended is shown in Figure D-1.

D-4. Current Cape May Inlet Navigation Project. The project at Cape May Inlet was authorized by the Congress in 1907 and modified in 1945. It provides for an entrance channel 25 feet deep at mean low water (mlw) and 400 feet wide protected by two parallel jetties 850 feet apart. The channel extends from the 25-foot-depth contour in the Atlantic Ocean to a line 500 feet harborward of a line joining the landward ends of the jetties, and thence is 20 feet deep and 300 feet wide to deep water in Cape May Harbor. The project length is about 2-1/4 miles. The project was completed in 1942 as a World War II emergency measure prior to formal authorization at a cost of $879,275, exclusive of $50,000 Department of the Navy funds and $100,000

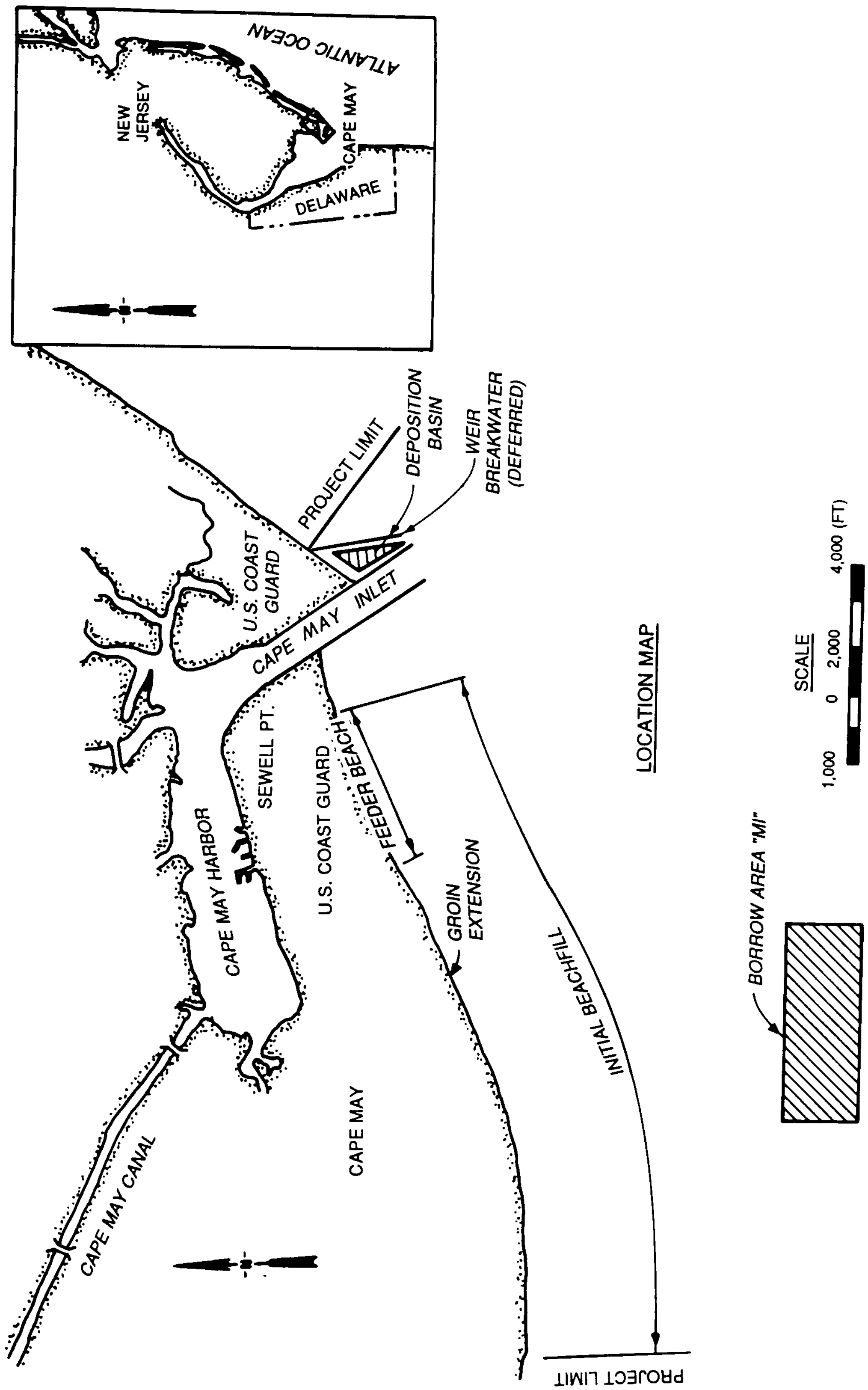


Figure D-1. Cape May Inlet to Lower Township, New Jersey Project contributed funds. The jetties were rehabilitated during the 1964-1965 period at a total cost of $1,134,346. The total cost of the project to 30 September 1978, including new work, jetty rehabilitation, and maintenance, is $3,703,318. The plan of the project is shown in Figure D-2.

## Section II. Navigation Project History

D-5. Cape May Inlet Entrance Jetties. The US Government constructed two parallel stone jetties at this inlet between 1908 and 1911 under a navigation project adopted by Congress in 1907. The project was modified in 1945. Maintenance work on the jetties was accomplished during 1914-1915, 1915-1916, 1918, 1922-1923, 1926-1927, and 1946. Restoration of the jetties was

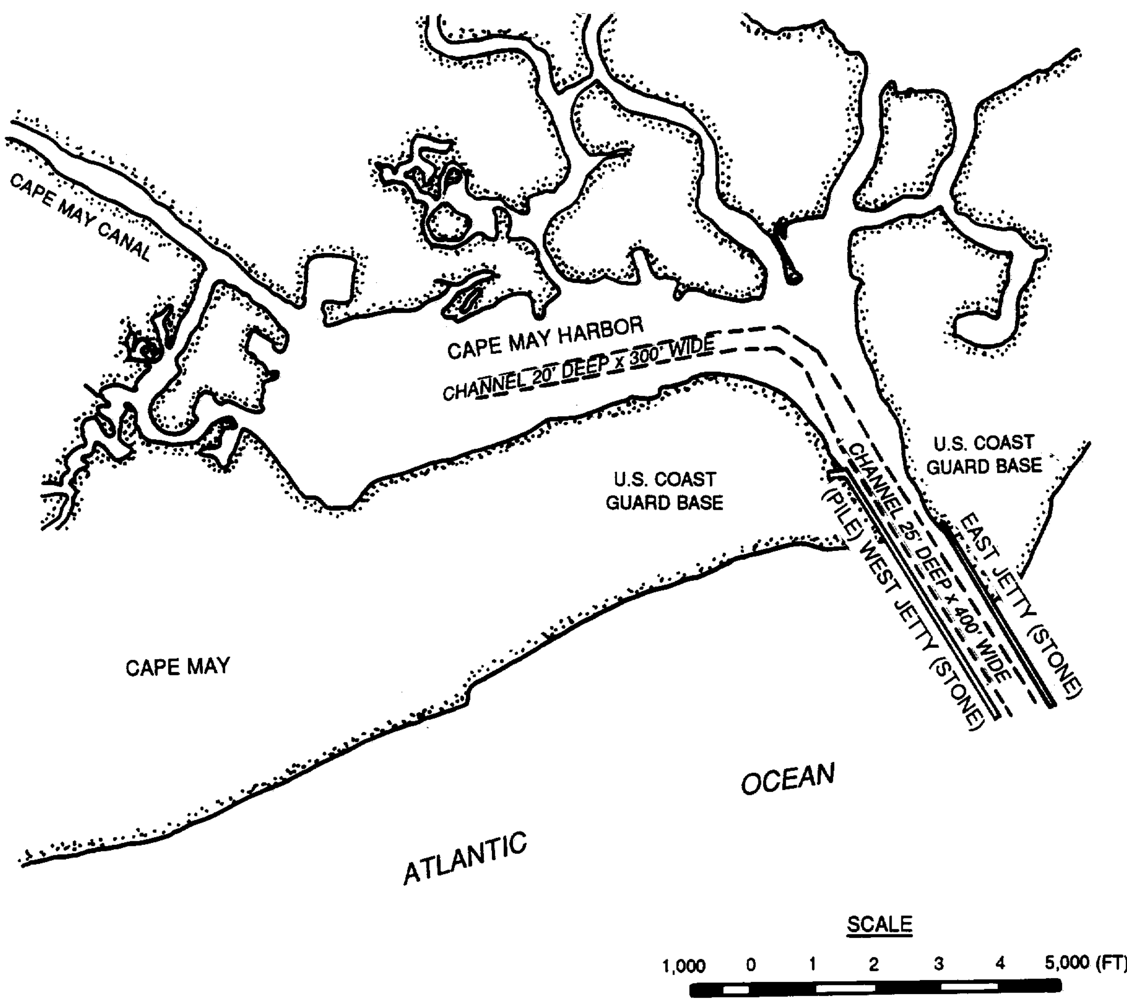


Figure D-2. New Jersey Intracoastal Waterway initiated in April 1964 and completed in October 1965. The seaward 2,390 feet of the northeast jetty and 3,385 feet of the southwest jetty were rehabilitated and restored to a top elevation of 10 feet above mlw. These jetties have accomplished their purpose of protecting the inlet channel. However, since the jetties were completed in 1911, much of the net southwestward littoral drift has been impounded upcoast of the northeast jetty or diverted offshore. The result has been erosion downcoast of the inlet and accretion updrift.

D-6. Maintenance Dredging Analysis. The Cape May Inlet maintenance dredging record to date reflects the inlet behavior under "without project" conditions, i.e., in the absence of a sand bypassing project. By determining the maintenance dredging quantities that involve sand of littoral origin, it is then possible to estimate the potential reduction in inlet maintenance costs that could result from implementing a program of sand bypassing.

a. Corps Annual Reports. The initial step in compiling a maintenance dredging history for this project involved a review of all US Army Corps of Engineers (USACE) annual reports from 1918, when inlet channel construction to authorized dimensions was completed, through the 1986 annual report. Each annual report was reviewed to determine if maintenance dredging was performed during the preceding fiscal year, and if so, information was recorded on the quantity dredged and the location of work. A summary of the information obtained from annual reports is presented in Table D-1, which compiles data on Cape May Inlet maintenance dredging activities for the 1918-1986 period. Dredged quantities are presented by fiscal year as well as cumulatively. The same information is presented graphically on Figures D-3 and D-4. Figure D-3 is a histogram showing maintenance dredging quantities by fiscal year. Figure D-4 shows that the cumulative maintenance dredging quantity, irrespective of location, for the Cape May Inlet and Harbor Project over the 1918 to 1986 period is 60,496 cubic yards per year.

b. History of Dredging Requirements. When evaluating the maintenance dredging history of this project, it is necessary to recognize the occurrence of a number of events that have had an influence on the dredged quantities. From 1918 until 1945, the authorized project consisted of the Cape May Inlet jetties and the 25-foot-deep by 400-foot-wide navigation channel through the inlet. The channel extended from the 25-foot depth in the ocean to a point 500 feet landward of the inner end of the jetties. From this point, a channel extended west into Cape May Harbor, which was dredged between 1903 and 1913 by private interests to a depth of about 30 feet,but at that time was not part of the authorized inlet project. (During this period, a principal user of the harbor as well as the inlet channel was the US Navy and later, the US Coast Guard.) In 1942, the channel between the landward terminus of the inlet project and Cape May Harbor was dredged by the US Navy to dimensions of 300 feet wide by 20 feet deep. However, it was not until 1945 that this channel extension into Cape May Harbor was adopted as a feature of the authorized project. Also in 1942, the Cape May Canal was constructed, providing access from Cape May Harbor west into Delaware Bay. Since 1945, maintenance dredging required in Cape May Harbor has been included in the maintenance dredging quantities presented in the annual reports.

c. Hopper Dredge Records. Because the annual reports typically do not include detailed information on the type of material removed during

Table D-1

Cape May Inlet and Harbor Maintenance Dredging History

| Fiscal Year | Quantity cy | Cumulative Quantity cy | Location of Work Inlet | Location of Work Harbor |
|---|---|---|---|---|
| 1918 | 990 | 990 | X | |
| 1919 | 42,265 | 43,255 | X | |
| 1920 | 0 | 43,255 | | |
| 1921 | 0 | 43,255 | | |
| 1922 | 0 | 43,255 | | |
| 1923 | 112,569 | 155,824 | X | |
| 1924 | 0 | 155,824 | | |
| 1925 | 287,990 | 443,814 | X | |
| 1926 | 0 | 443,814 | | |
| 1927 | 0 | 443,814 | | |
| 1928 | 0 | 443,814 | | |
| 1929 | 0 | 443,814 | | |
| 1930 | 0 | 443,814 | | |
| 1931 | 0 | 443,814 | | |
| 1932 | 0 | 443,814 | | |
| 1933 | 664,458 | 1,108,272 | X | |
| 1934 | 0 | 1,108,272 | | |
| 1935 | 0 | 1,108,272 | | |
| 1936 | 141,027 | 1,249,299 | X | |
| 1937 | 0 | 1,249,299 | | |
| 1938 | 161,959 | 1,411,258 | X | |
| 1939 | 0 | 1,411,258 | | |
| 1940 | 261,147 | 1,672,405 | X | |
| 1941 | 236,419 | 1,908,824 | X | |
| 1942 | 177,360 | 2,086,184 | X | |
| 1943 | 0 | 2,086,184 | | |
| 1944 | 179,300 | 2,265,484 | X | |
| 1945 | 70,560 | 2,336,044 | X | |
| 1946 | 0 | 2,336,044 | | |
| 1947 | 0 | 2,336,044 | | |
| 1948 | 0 | 2,336,044 | | |
| 1949 | 0 | 2,336,044 | | |
| 1950 | 163,128 | 2,499,172 | X | |
| 1951 | 0 | 2,499,172 | | |
| 1952 | 0 | 2,499,172 | | |
| 1953 | 0 | 2,499,172 | | |
| 1954 | 95,491 | 2,594,663 | X | |
| 1955 | 0 | 2,594,663 | | |
| 1956 | 0 | 2,594,663 | | |
| 1957 | 0 | 2,594,663 | | |
| 1958 | 32,267 | 2,626,930 | X | |
| 1959 | 0 | 2,626,930 | | |
| 1960 | 115,870 | 2,742,800 | X | |
| 1961 | 122,709 | 2,865,509 | | X |
| 1962 | 118,489 | 2,983,998 | X | X |

(Continued)

Table D-1 (Concluded)

| Fiscal Year | Quantity cy | Cumulative Quantity cy | Location of Work Inlet | Location of Work Harbor |
|---|---|---|---|---|
| 1963 | 0 | 2,983,998 | | |
| 1964 | 401,723 | 3,385,721 | X | X |
| 1965 | 155,749 | 3,541,470 | | X |
| 1966 | 178,966 | 3,720,436 | X | X |
| 1967 | 29,217 | 3,749,653 | X | X |
| 1968 | 0 | 3,749,653 | | |
| 1969 | 18,271 | 3,767,924 | X | X |
| 1970 | 0 | 3,767,924 | | |
| 1971 | 44,233 | 3,812,157 | X | X |
| 1972 | 0 | 3,812,157 | | |
| 1973 | 69,910 | 3,882,067 | X | X |
| 1974 | 0 | 3,882,067 | | |
| 1975 | 27,232 | 3,909,299 | X | X |
| 1976 | 0 | 3,909,299 | | |
| 1977 | 49,255 | 3,958,554 | X | X |
| 1978 | 0 | 3,958,554 | | |
| 1979 | 0 | 3,958,554 | | |
| 1980 | 0 | 3,958,554 | | |
| 1981 | 0 | 3,958,554 | | |
| 1982 | 0 | 3,958,554 | | |
| 1983 | 194,400 | 4,152,954 | | X |
| 1984 | 17,800 | 4,170,754 | X | |
| 1985 | 0 | 4,170,754 | | |
| 1986 | 3,502 | 4,174,256 | X | |
| | Total | 4,174,256 | | |

maintenance dredging, information was also obtained from US Government hopper dredge records available for the period from 1942 through 1986. These records generally provide a greater level of detail than is provided in the annual reports and include information on dredged quantities and method of volume computation (i.e., "haul" versus "pay" yardage), location of dredging, disposal area, and type of material dredged. The hopper dredge data for the project are summarized in Table D-2, showing annual as well as cumulative values. The same data are presented in Figure D-5 (by calendar year) and in Figure D-6 (cumulatively).

d. Variations in Dredging Requirements. It can be seen from Figure D-5 that both the frequency of dredging and quantity dredged have varied considerably over the 1942 to 1986 period. For example, note the 6-year period from 1960 through 1965, when the project was dredged each year, with "haul" quantities exceeding 100,000 cubic yards each year. In contrast, note that the project was not dredged at all in the 5-year period from 1978 through 1982. Although these records document the dredging history for the project, they do not explain why relatively large variations occur in both frequency and volume of maintenance dredging.

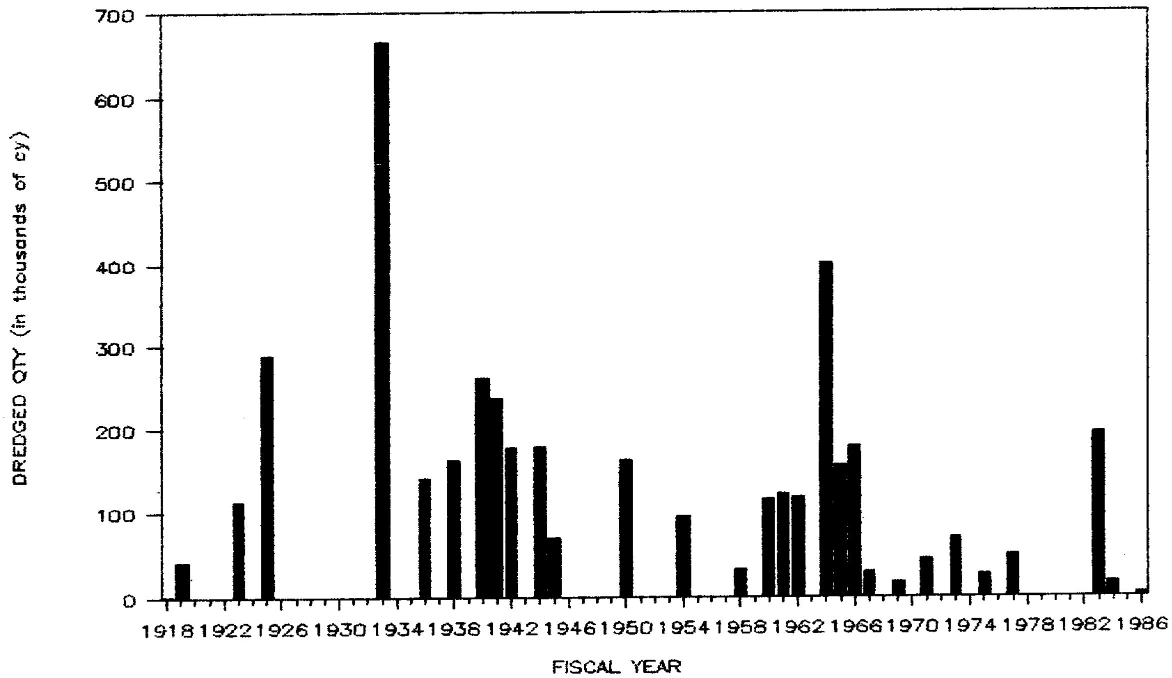


Figure D-3. Cape May Inlet and Harbor Maintenance dredging by fiscal year

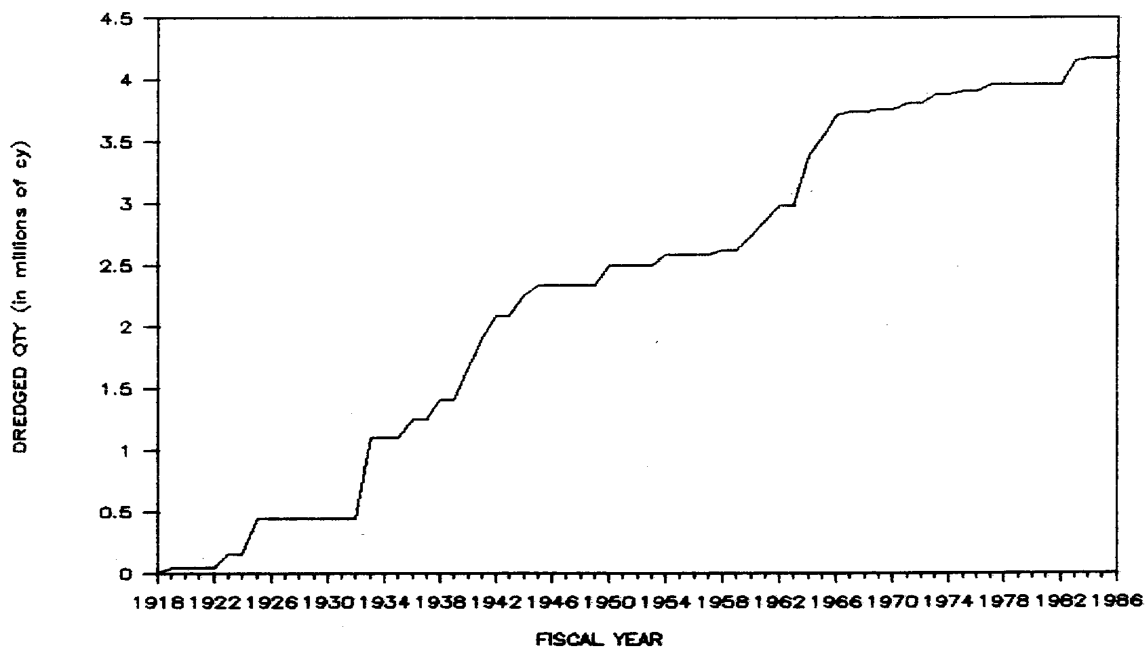


Figure D-4. Cape May Inlet and Harbor cumulative maintenance dredging

Table D-2

Cape May Inlet and Harbor Maintenance Dredging Quantities

| | YEAR | HAUL | PAY | EXCESS | TOTAL (PAY+EXCESS) | CUM HAUL | CUM TOTAL(P+E) | HAUL/(P+E) RATIO | LOCATION OF WORK INLET | LOCATION OF WORK HARBOR |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1942 | 139,410 | 65,864 | 0 | 65,864 | 139,410 | 65,864 | 212% | x | |
| | 1943 | 0 | 0 | 0 | 0 | 139,410 | 65,864 | | | |
| | 1944 | 179,300 | 180,494 | 0 | 180,494 | 318,710 | 246,358 | 99% | x | |
| | 1945 | 70,560 | 33,507 | 0 | 33,507 | 389,270 | 279,865 | 211% | x | |
| | 1946 | 0 | 0 | 0 | 0 | 389,270 | 279,865 | | | |
| | 1947 | 0 | 0 | 0 | 0 | 389,270 | 279,865 | | | |
| | 1948 | 0 | 0 | 0 | 0 | 389,270 | 279,865 | | | |
| | 1949 | 163,128 | 179,917 | 0 | 179,917 | 552,398 | 459,782 | 91% | | |
| | 1950 | 0 | 0 | 0 | 0 | 552,398 | 459,782 | | x | |
| | 1951 | 0 | 0 | 0 | 0 | 552,398 | 459,782 | | | |
| | 1952 | 0 | 0 | 0 | 0 | 552,398 | 459,782 | | | |
| | 1953 | 0 | 0 | 0 | 0 | 552,398 | 459,782 | | | |
| | 1954 | 164,084 | 95,491 | 27,111 | 122,602 | 716,482 | 582,384 | 134% | x | |
| | 1955 | 0 | 0 | 0 | 0 | 716,482 | 582,384 | | | |
| | 1956 | 0 | 0 | 0 | 0 | 716,482 | 582,384 | | | |
| | 1957 | 0 | 0 | 0 | 0 | 716,482 | 582,384 | | | |
| | 1958 | 68,961 | 32,961 | 0 | 32,961 | 785,443 | 615,345 | 209% | x | |
| | 1959 | 0 | 0 | 0 | 0 | 785,443 | 615,345 | | | |
| | 1960 | 115,870 | 54,801 | 45,930 | 100,731 | 901,313 | 716,076 | 115% | x | |
| | 1961 | 122,709 | 100,518 | 0 | 100,518 | 1,024,022 | 816,594 | 122% | | x |
| | 1962 | 118,489 | 87,574 | 0 | 87,574 | 1,142,511 | 904,168 | 135% | x | x |
| | 1963 | 401,723 | 205,380 | 83,598 | 288,978 | 1,544,234 | 1,193,146 | 139% | | |
| | 1964 | 155,749 | 105,842 | 45,035 | 150,877 | 1,699,983 | 1,344,023 | 103% | x | x |
| | 1965 | 178,966 | 188,150 | 110,170 | 298,320 | 1,878,949 | 1,642,343 | 60% | | x |
| | 1966 | 0 | 0 | 0 | 0 | 1,878,949 | 1,642,343 | | x | x |
| | 1967 | 29,217 | 18,990 | 0 | 18,990 | 1,908,166 | 1,661,333 | 154% | x | x |
| | 1968 | 0 | 0 | 0 | 0 | 1,908,166 | 1,661,333 | | | |
| | 1969 | 18,271 | 42,707 | 6,768 | 49,475 | 1,926,437 | 1,710,808 | 37% | x | x |
| | 1970 | 0 | 0 | 0 | 0 | 1,926,437 | 1,710,808 | | | |
| | 1971 | 44,233 | 19,510 | 9,984 | 29,494 | 1,970,670 | 1,740,302 | 150% | x | x |
| | 1972 | 0 | 0 | 0 | 0 | 1,970,670 | 1,740,302 | | | |
| | 1973 | 69,910 | 53,199 | 4,661 | 57,860 | 2,040,580 | 1,798,162 | 121% | x | x |
| | 1974 | 0 | 0 | 0 | 0 | 2,040,580 | 1,798,162 | | | |
| | 1975 | 40,697 | 26,253 | 5,696 | 31,949 | 2,081,277 | 1,830,111 | 127% | x | x |
| | 1976 | 0 | 0 | 0 | 0 | 2,081,277 | 1,830,111 | | | |
| | 1977 | 49,255 | 31,491 | 12,795 | 44,286 | 2,130,532 | 1,874,397 | 111% | x | x |
| | 1978 | 0 | 0 | 0 | 0 | 2,130,532 | 1,874,397 | | | |
| | 1979 | 0 | 0 | 0 | 0 | 2,130,532 | 1,874,397 | | | |
| | 1980 | 0 | 0 | 0 | 0 | 2,130,532 | 1,874,397 | | | |
| | 1981 | 0 | 0 | 0 | 0 | 2,130,532 | 1,874,397 | | | |
| | 1982 | 0 | 0 | 0 | 0 | 2,130,532 | 1,874,397 | | | |
| CONTRACT> | 1983 | 102,487 | 102,140 | 347 | 102,487 | 2,233,019 | 1,976,884 | 100% | | x |
| SIDECAST> | 1984 | 70,971 | 35,485 | 0 | 35,485 | 2,303,990 | 2,012,369 | 200% | x | |
| | 1985 | 12,120 | 8,676 | 29,550 | 38,226 | 2,316,110 | 2,050,595 | 32% | | |
| | 1986 | 16,850 | 13,825 | 3,502 | 17,327 | 2,332,960 | 2,067,922 | 97% | x | |
| | TOTAL | 2,332,960 | 1,682,775 | 385,147 | 2,067,922 | | | # OF DREDGINGS = | 18 | 12 |
| | AVERAGE ANNUAL | 51,844 | 37,395 | 8,559 | 45,954 | | | | | |

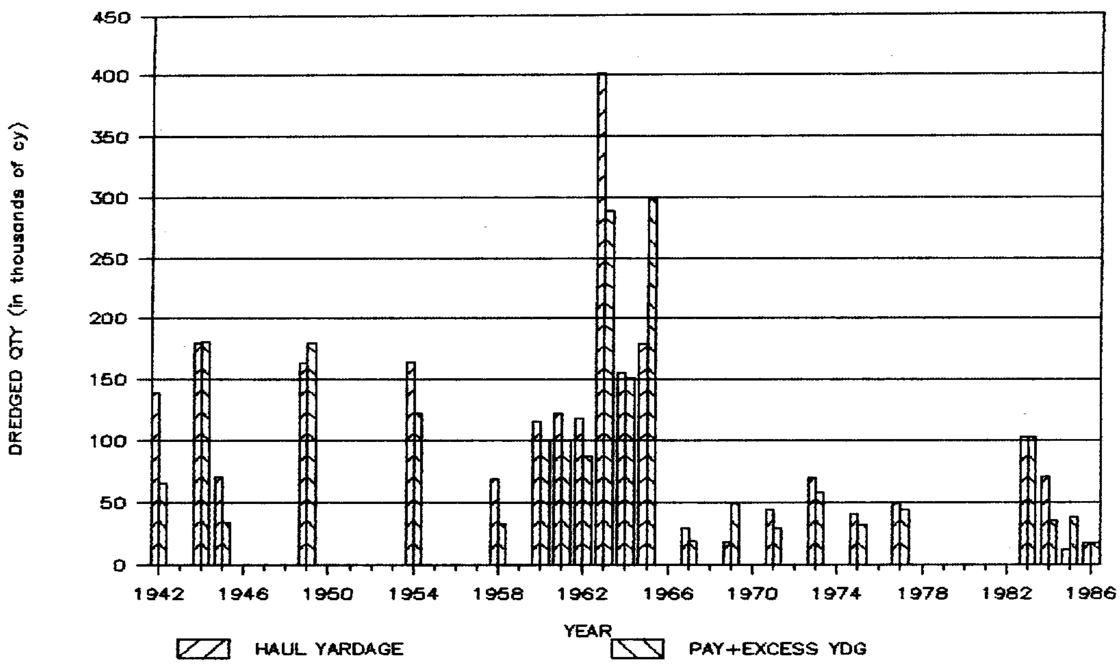


Figure D-5. Cape May Inlet and Harbor maintenance dredging by calendar year

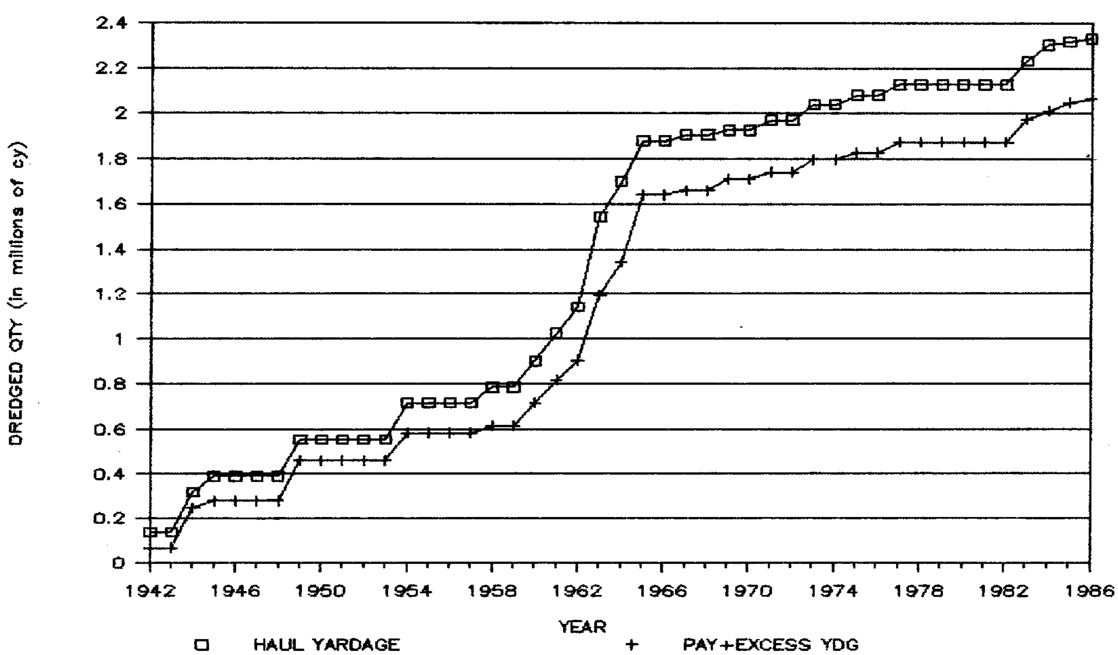


Figure D-6. Cape May Inlet and Harbor cumulative maintenance dredging, calendar year

e. Explanation of Hopper Dredge Quantities. Table D-2 also illustrates an important point regarding the use of annual reports and/or Government hopper dredge records in a sediment budget analysis. For example, in Table D-2, note that there are columns reporting "haul," "pay," and "excess" quantities as well as the ratios of "haul" to "pay" plus "excess" quantities. The term "haul" refers to a dredged quantity calculated as the product of the hopper capacity of the dredge used times the number of hopper loads dredged. The terms "pay" and "excess" quantity are generally based on calculations using before- and after-dredging hydrographic surveys of the navigation channel. The "pay" quantity is the measured volume removed down to the limit of the design channel prism specified for a particular dredging operation. The "excess" quantity is the measured volume removed beyond (i.e., either deeper than or outside of) the specified channel prism for a particular dredging operation. The sum of "pay" plus "excess" quantities should then represent the best estimate of the actual quantity removed during dredging. However, the reported "haul" quantities generally exceed the calculated "pay plus excess" quantities. Over the 1942-1986 period, the average annual "haul" value exceeds the average annual "pay plus excess" value by 13 percent. This is probably because much of the "haul" value includes material of higher water content than "pay" plus "excess" quantities.

## Section III. Sediment Transport

D-7. Sand Bypassing Quantities. The analysis of sand bypassing quantities at Cape May Inlet was based on the Phase I General Design Memorandum (GDM) analysis (USAED, Philadelphia 1980) and the results of sand bypassing and sediment transport programs developed by the USAED, Jacksonville, and modified by the USAED, Philadelphia. The Phase I GDM presented the results of a detailed shore processes analysis performed by the Coastal Engineering Research Center (CERC) for the USAED, Philadelphia. This analysis evaluated shoreline change rates, sediment volume change rates, and onshore/offshore and longshore sediment transport rates for Cape May Inlet and vicinity. A more detailed analysis of sediment transport to determine an optimum sand bypass pumping capacity for design purposes was accomplished using modified versions of the USAED, Jacksonville, programs. The sediment budget analysis for the Cape May Inlet vicinity shows that the annual northeasterly longshore transport rate is 250,000 cubic yards per year; the annual southwesterly longshore transport rate is 500,000 cubic yards per year; and the net longshore transport rate is 250,000 cubic yards per year to the southwest. The general sediment transport budget is shown in Figure D-7.

a. Wave Hindcast Analysis. A sequence of three programs are used by the USAED, Philadelphia, in conjunction with 20 years of wave hindcast data developed by the USACE Wave Information Study (WIS). These data contain values for swell height, period and direction and sea height, period and direction in 3-hour intervals for the period 1956 to 1975. The first program of the sequence converts WIS data to English units and adjusts the data to the correct shoreline orientation. The second program refracts waves from shallow water to the shoreline resulting in computations of significant breaker height, period, and direction for each 3-hour hindcast. Wave refractions are based on the Goda shoaling methodology, as discussed in the CERC publication TP-80-3, "Estimating Nearshore Conditions for Irregular Waves" (Seelig and Ahrens 1980), which requires an estimate of a directional spreading parameter and the slope of the sea bottom from shallow water to the shoreline. The

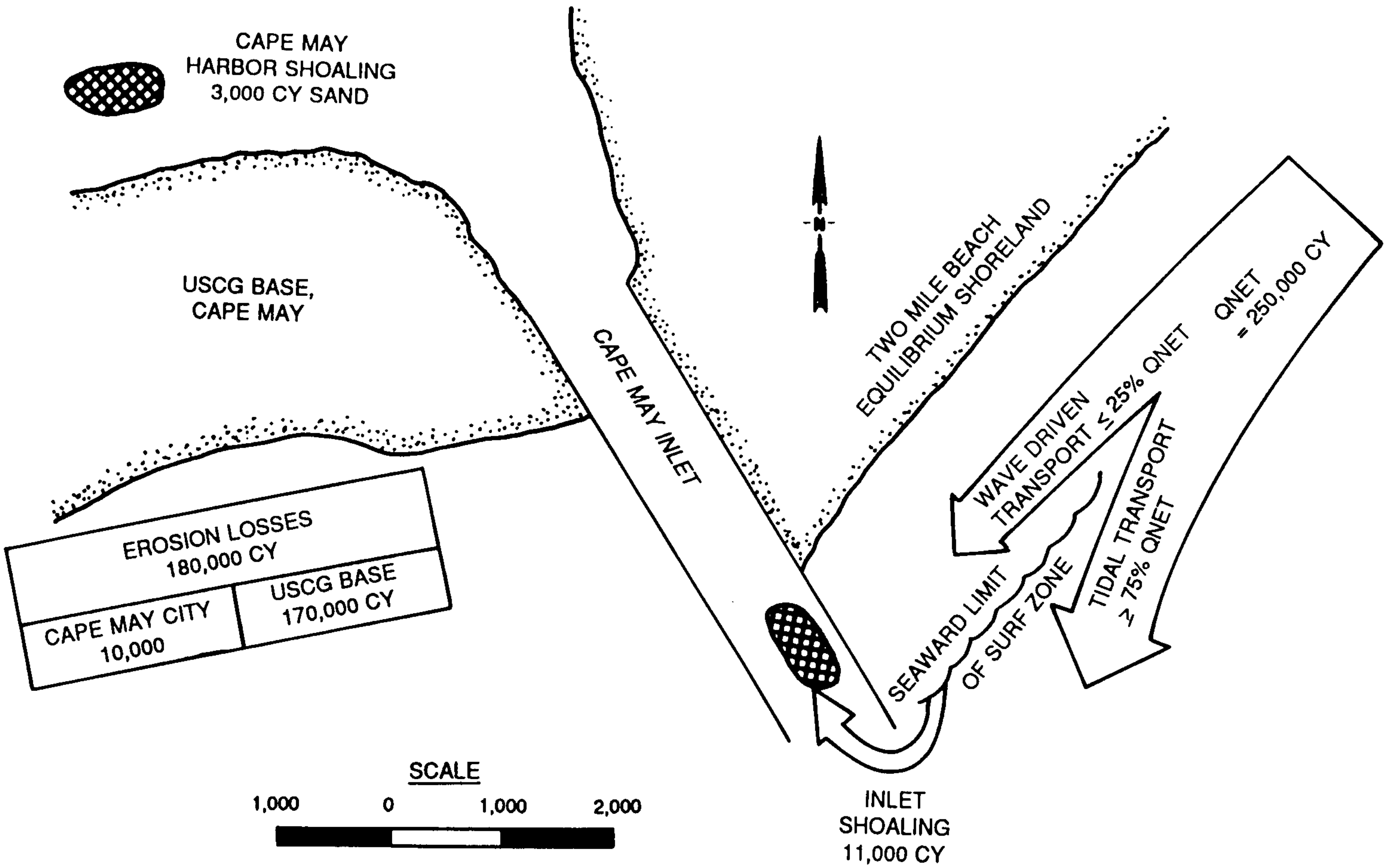


Figure D-7. General sediment budget at Cape May Inlet, New Jersey third program computes longshore transport rates from the transformed wave data and the resulting sand bypass rate given various bypassing parameters. Altering the bypassing parameters for each computer run enables an optimum sand bypass rate to be determined.

b. Longshore Transport Calculation. For each 3-hour hindcast, an estimate of longshore transport was computed from Equations 4-44 and 4-50b, of the Shore Protection Manual (SPM) (1984):

$$Q = 7500\ P_{ls} \qquad (4\text{-}50b)$$

and

$$P_{ls} = (0.0884)(\rho_s)(g^{3/2})(H_{sb}^{5/2})(\sin 2\ \alpha_b) \qquad (4\text{-}50b)$$

where

$Q$ = longshore transport rate
$P_{ls}$ = longshore energy flux
$_s$ = mass density of salt water
$g$ = acceleration due to gravity
$H_{sb}$ = significant breaker height
$\alpha_b$ = breaking wave angle

These equations were used to compute mean southwestward, mean northeastward, net, gross, and optimum pumping capacities of a sand bypass system over the 1956-75 period at Cape May Inlet.

c. Summary of Transport Rate Values. In using the sand bypassing and sediment transport programs at Cape May, two major assumptions were made: seasonal trends of the WIS data are correct and the mean southwest component of sediment transport equals 500,000 cubic yards per year, the figure adopted in the Cape May Inlet to Lower Township, Phase I GDM. It was felt that shallow-water data alone cannot be used to accurately predict estimates of total longshore transport since there are other physical factors involved in sediment transport processes. However, since the seasonal trends are reasonable, the southwest component of longshore transport (i.e. the material transported to the bypass plant) was adjusted to match the GDM figure of 500,000 cubic yards per year. The values of sediment transport obtained are summarized in Table D-3. The results of the analysis determined that net

Table D-3

Summary of Longshore Transport Values. Cubic Yards per Year

| Parameter | Phase I GDM | WIS Values |
|---|---|---|
| Southwest | 500,000 | 502,000 |
| Northeast | 250,000 | 407,000 |
| Net | 250,000 | 95,000 |
| Gross | 750,000 | 909,000 |

sediment transport at Cape May is northward during April through August and southward during September through March. The piping plover (an endangered shore bird) nesting season coincides with the period of northward transport (April-August). Since bypassing sand during periods of northward transport would not benefit downdrift beaches and bypassing operations during these months would also impact the nesting habits of the piping plover, it was decided to restrict sand bypassing to the months of September through March.

d. Bypassing Consideration. Another analysis was made (see Table D-4) in which no bypassing would take place during the winter months of January and February and the piping plover nesting season. The results of the analysis indicated that insufficient sand bypassing quantities would occur with this much of a time restriction. The sand transport parameters used in determining the optimum sand bypassing rate and the computed bypass rates are summarized in Tables D-4 and D-5.

Table D-4

Sand Bypassing Parameters Used

| Parameter | Value |
|---|---|
| Beach Slope | 1:30 |
| Shoreline orientation | 51° |
| Water depth at area of interest | 25 ft |
| Directional spreading parameter | 12 |
| Refraction angle increment | 2° |
| Computation time step | 3 hr |
| Southward net transport | 500,000 cy/yr |
| Longshore transport equation | SPM 4-44/4-50B |
| Fraction of sand retained at jetty | 100% (i.e. no weir) |
| Basin storage volume | 10,000 $yd^3$ |
| Pump cycle (not used by program) | 1 |

e. Recommended Pumping Capacity. Based on these results, a pumping capacity of 400 cubic yards per hour is recommended. A sand bypass system operating at this rate should be able to provide the necessary volumes to the feeder beach and should be flexible enough to provide sufficient bypass quantities to handle the maximum ranges of longshore sediment transport at Cape May.

D-8. Harbor and Inlet Shoaling Analysis. The discussion in Section II of this appendix on the project maintenance dredging history indicated that dredging records alone were not sufficiently detailed for purposes of a sediment budget analysis. In order to provide the necessary quantitative information needed for a sediment budget for the project, two principal tasks were performed. The first task included the analysis of hydrographic surveys of the inlet and harbor to define specific shoaling problem areas and to derive estimates of shoaled quantities and rates. The second task consisted of a field investigation of the inlet and harbor to define the spatial distribution of sediment types in the shoaling areas. The following paragraphs describe the methods and results of these two tasks, which were then

Table D-5

Sand Bypass Rate Analysis

| Period of Operation | Pump Capacity cy/hr | Maximum Pumping Hours/Day* | Average Bypass Volume per year** |
|---|---|---|---|
| All 12 months | 150 | 6 | 184,000 |
| All 12 months | 200 | 6 | 200,000 |
| All 12 months | 250 | 6 | 223,800 |
| All 12 months | 250 | 3 | 168,000 |
| All 12 months | 275 | 3 | 176,450 |
| All 12 months | 300 | 3 | 183,700 |
| Mar - Dec | 200 | 6 | 169,131 |
| Mar - Dec | 250 | 6 | 182,400 |
| Mar - Dec | 400 | 3 | 168,660 |
| Mar - Dec | 450 | 3 | 175,484 |
| Mar - Dec | 500 | 3 | 181,538 |
| Sep - Mar | 400 | 6 | 186,308+ |
| Sep - Mar | 775 | 3 | 183,194 |
| Sep - Dec/Mar | 750 | 6 | 165,227 |

* These values represent the maximum number of hours of plant operation. Actual operating hours vary depending on the amount of material pumped.

** The desired average sand bypass volume is 180,000 cy/yr. The optimum design pumping capacity was determined by trial and error method of altering the sand bypass parameters.

\+ Selected pumping capacity.

synthesized in order to represent as accurately as possible the sediment budget of the project under current operating conditions as well as the scenario in which sand bypassing is implemented.

D-9. Hydrographic Survey Analysis. The project consists of and was analyzed as two discrete segments: the inlet channel, located between the jetties with authorized dimensions of 400 feet wide, 25 feet deep, and approximately 5,000 feet long; and the harbor channel, which begins at the landward terminus (Station 0+000) of the inlet channel, with authorized dimensions of 300 feet wide, 20 feet deep, and approximately 6,500 feet long (Figure D-8). Based on the information developed in the maintenance dredging analysis, it was determined that the detailed analysis of shoaling locations and rates would include the period beginning in September 1965 and extending to the most recent survey date available for this study, August 1986. This period was selected for two reasons: first, there was a complete hydrographic survey data set available for the 1965-1986 period; and second, the maintenance dredging practices, in terms of locations dredged and depths maintained, were more uniform over this period.

a. The first step in the shoaling analysis was to obtain all hydrographic surveys available for the inlet and harbor reaches of the project for the 1965 to 1986 period. For the inlet reach, there was a total of 26

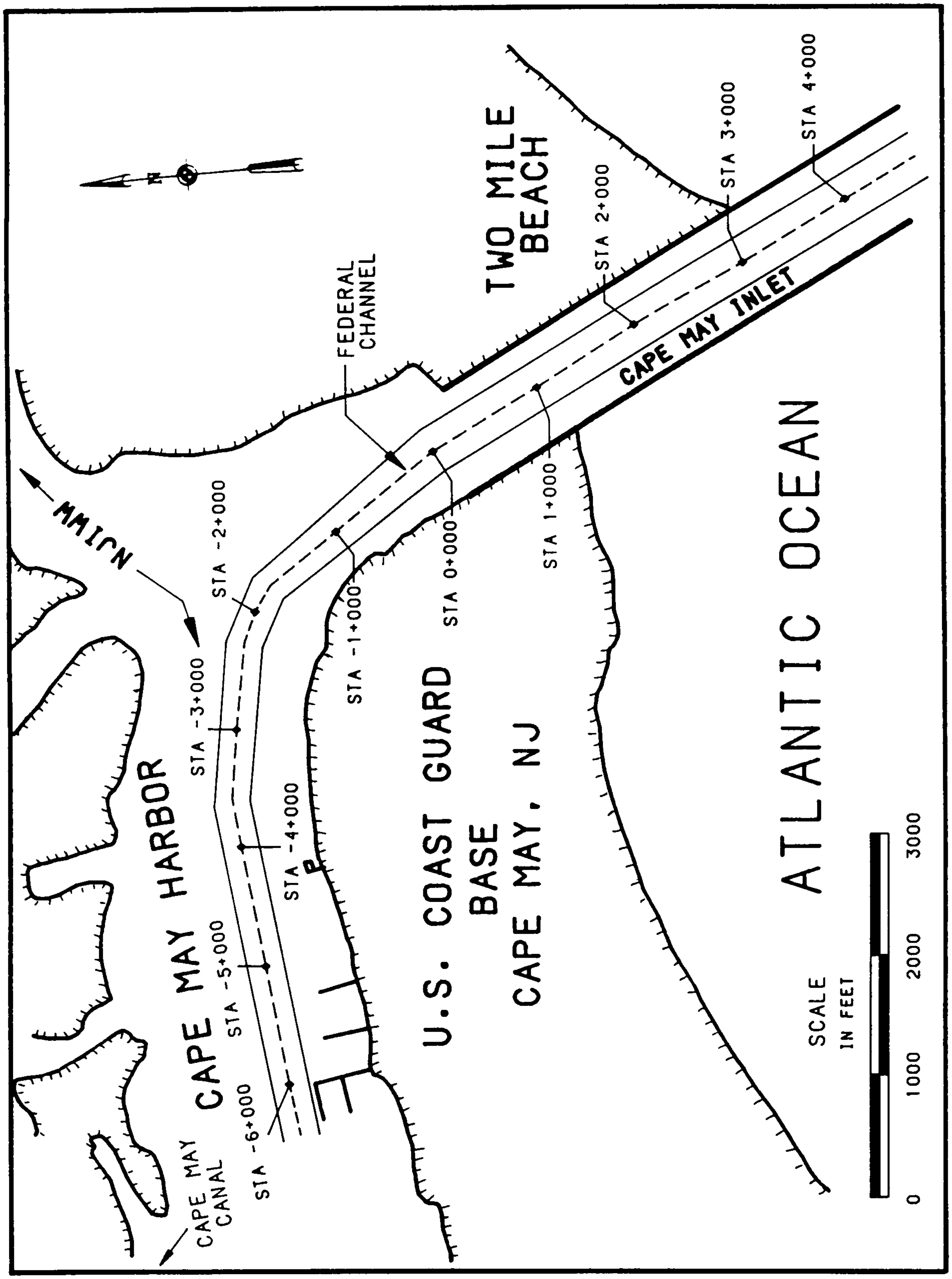


Figure D-8. Hydrographic survey stations hydrographic surveys available, including periodic channel examinations as well as predredging and postdredging surveys. The channel exams typically cover the entire 5,000-foot-long inlet reach, whereas the predredging and postdredging surveys usually include a smaller area (the area dredged) in greater detail than on the exams. In the harbor reach over the 1965 to 1986 period, there was a total of 19 hydrographic surveys available. The smaller number of harbor surveys is due to the facts that there were no harbor surveys or dredging between March 1979 and February 1983 and the harbor was not dredged between 1984 and 1986, a time in which the inlet was dredged annually.

b. The second step in the shoaling analysis involved selecting index stations within each reach. These stations were selected as being representative of the adjacent channel area and on the basis of locations for which survey data were available on the largest number of surveys. In the inlet reach, a total of 17 stations was selected, with 10 stations spaced 400 feet apart between Stations 0+000 (inner end of inlet channel) and 3+600 to 5+000. In the harbor, a total of 10 index stations was selected with a variable spacing of between 600 and 900 feet.

c. The third step involved calculating the mean depth for the northeast and southwest halves of the channel at each index station in the inlet for each available survey. A similar operation was performed for the north and south halves of the channel at each harbor index station. These data were compiled into a computerized spread sheet format, which thus represented the most complete record possible of depth as a function of time at the two half-channel segments for each harbor and inlet index station.

d. From this data base, the fourth step involved calculations of the following parameters: depth change over the interval between surveys, shoaling rate for each interval, and the volumetric equivalent of the depth change times the plan area of channel represented by the index station value. The convention adopted in this analysis was that positive depth change values represented shoaling (depth decreases over time), whereas negative depth change values represented dredging or scour (depth increases over time). Maintenance dredging records and predredging and postdredging surveys were used to distinguish dredging-related depth increases from scour-related (i.e. natural) depth increases.

e. The fifth step in this analysis involved the determination of the long-term mean shoaling characteristics for each half of each index station over the period of record adopted, 1965-1986. The long-term shoaling rate determination typically included the following sequence for each index station in the project:

(1) Determine the actual depth change from the earliest to the latest survey date. This is termed the "apparent" long-term depth change.

(2) Determine the sum of all dredging-related depth increases at all index stations where dredging was performed over the period of record.

(3) Subtract the sum of the dredging-related depth increases from the "apparent" long-term depth change to establish the total one-dimensional shoaling which occurred at that index station over the period of record.

(4) Multiply the one-dimensional shoaling by the appropriate channel surface area to determine the total volume which shoaled by the length of the period of record in years to determine the corresponding long-term volumetric shoaling rate for each sub-area.

D-10. Inlet Shoaling. Shoaling within the inlet reach is essentially confined to a zone near the ocean entrance to the project, specifically between Stations 3+400 and 4+900 on the northeast half of the channel and between Stations 3+400 and 4+100 on the southwest half of the channel. This is the only significant shoaling zone within the inlet and has accumulated an average of about 11,000 cubic yards per year over the 1965-1986 period.

a. East (seaward) of the zone described in the above paragraph, the channel has not required dredging over the period of record and has in fact exhibited a tendency to scour.

b. West (landward) of the zone described above, the channel has been dredged only once with a total of less than 3,000 cubic yards removed. This zone is 3,400 feet long and appears to be approximately in equilibrium with its hydraulic and sedimentary environment. It was assumed that the long-term shoaling rate in this zone is zero.

D-11. Harbor Shoaling. The easternmost 2,000-foot segment of the harbor channel has required no maintenance dredging over the period of record and, in fact, has scoured an average of about 2 feet in that time. There is no indication that this zone will require maintenance dredging in the future. However, the 1,500-foot-long zone from harbor Stations -2+000 west to -3+500 has been dredged on each of the seven maintenance operations described above. The average annual shoaling rate in this zone has been approximately 18,000 cubic yards per year over the period of record.

D-12. Sediment Analysis. The conclusions presented above are based on findings of the hydrographic survey analysis and represent the best estimate of the locations and rates at which sedimentary materials shoal (or scour) within the inlet and harbor reaches of the project. However, information available from the maintenance dredging analysis (presented in Section II) was not sufficient to reliably identify the sediment types that are present in the various segments of the project which experience shoaling. The identification of the types of sediment that accumulate in the shoaling zones is a critical parameter in identifying the source of shoaling. Because a sand bypassing operation is confined to the littoral zone adjacent to the inlet portion of the project, the only sediment type affected by the proposed bypassing is littoral sand. The sand bypassing operation would have no significant impact on any fine-grained (i.e. silt and clay) sedimentation within the project.

a. Field Study. Consequently, in April 1987, a 2-day field reconnaissance of sediment distribution within the harbor and inlet was performed. A total of 27 locations in the harbor and inlet channels were occupied and bottom sediment samples obtained.

(1) Samples collected indicate the bottom sediments that accumulate at the recurrent inlet shoal location are exclusively coarse-grained, i.e. sand, gravel, and shell fragments. These sediments probably originate from the updrift (northeast) jetty fillet. This pattern of accumulation at the inlet

throat is consistent with the predominant regional net southwestward sediment transport pattern. This littoral sediment transport system moves sediment alongshore to the vicinity of the jetty fillet and the ocean entrance of the inlet. Tidal currents are then capable of flushing the sediment into the inlet during flood or out of the inlet during ebb current conditions.

(2) The field reconnaissance also indicated that there is an estimated 50-percent fine sand content in the sediments which shoal in the harbor between Stations -2+000 and -3+500. Because the total rate at which this zone shoals was determined to be 6,000 cubic yards per year, the sand component was estimated to be 3,000 cubic yards per year. The inner 3,000-foot-long section of the harbor (between harbor Stations -3+500 and -6+500) is composed exclusively of fine-grained (i.e. silt and clay) sediments; there is no sand fraction present.

D-13. Inlet and Harbor Sediment Budget. Based on the findings of the maintenance dredging analysis, hydrographic survey analysis, and the field investigation, the following sediment budget was derived for the Cape May Inlet and Harbor Project given the maintenance dredging practices employed between 1965 and 1986 (Table D-6). From Table D-6, it can be seen that

Table D-6

Cape May Inlet and Harbor Sediment Budget, 1965-1986

| Shoal Location | Avg Annual Shoaling Qty. cubic yards | Percent Sand | Probable Sand Source |
|---|---|---|---|
| Inlet (near ocean entrance) | 11,000 | 100 | Littoral zone |
| Harbor (east end, 1,500 ft long) | 6,000 | 50 | Inlet Channel |
| Harbor (west end, 3,000 ft long) | 18,000 | 0 | -- |

11,000 cubic yards per year of sand, which probably originates from the littoral zone, shoal within the inlet channel. At the east end of the Cape May Harbor, the 6,000 cubic yards of sediments that shoal annually include an estimated 3,000 cubic yards of sand.

## Section IV. Previous Studies of Sediment Transport

D-14. General. This section of the appendix presents summaries of previous studies for the Cape May area that address the interrelated topics of coastal processes, longshore transport rates, and erosion and accretion.

D-15. House Document 206, 83rd Congress (1953). This House Document adopts the findings of a USAED, Philadelphia, study and report. The District report presents findings based on a review of shoreline and offshore surveys dating from 1842 to 1948, with more detailed surveys covering the 1927-1948 period. Information on pertinent physical factors, which include wind, waves, and currents, is also presented and used in the final interpretation and analysis of the sediment transport environment in the study area.

a. Transport Direction. This report documents the existence of a net sediment transport direction to the southwest along the study area shorelines, which extend from about 15,000 feet northeast of Cape May Inlet to Cape May Point. Evidence for this predominant southwestward transport includes both inlet migration patterns prior to 1908, as well as shoreline responses following the stabilization of Cape May Inlet by jetties between 1908 and 1911.

b. Transport Mechanisms. The physical mechanisms responsible for the southwestward transport were determined to be a combination of incident wave energy predominantly from the northeast, as well as nearshore tidal currents set up by the flood and ebb of the tidal prism of Delaware Bay. Measurements of nearshore current direction and speed were made along the study area shorelines on 17 occasions in 1949. These measurements indicated that the nearshore surface current direction was in phase with the tidal currents at the entrance to the Delaware Bay; that is, nearshore currents flowed to the southwest, towards the bay entrance, when the bay was flooding, and nearshore currents flowed to the northeast when the bay was ebbing. The reversing nearshore currents were detected as far as Wildwood Crest, which is 9 miles northeast of the bay entrance at Cape May Point.

c. Transport Quantities. From an analysis of survey data from the 1927 to 1948 period, it was determined that very large quantities of sediment, in excess of 1 million cubic yards per year, are transported along the study area, predominantly in the offshore zone. However, it was concluded that the primary cause of this transport was the nearshore circulation set up by Delaware Bay tidal effects. The portion of sediment transport attributed exclusively to the longshore component of the incident wave energy was concluded to be some undefined fraction of the total sediment load transported in the nearshore zone.

d. Transport Estimate. The report estimated the longshore transport rate for the vicinity of Cape May Inlet, based on the accumulation rate on the east jetty fillet over several years following jetty completion. This rate of accumulation was found to be about 100,000 cubic yards per year, with an assumed component of equal magnitude passing the fillet area, for a total net transport rate of 200,000 cubic yards per year to the southwest. The report further concluded that by 1934 the east jetty fillet had attained a near-equilibrium configuration and was no longer acting as a site of significant net accretion.

e. Transport Erosion. The erosion experience along the shoreline west of the west jetty was attributed to the seaward diversion of the net southwestward longshore transport. As this material is transported past the east jetty in the net southwestward direction, it is subject to redistribution over a relatively large zone because of the combined tidal and wave-driven components of the nearshore current regime. There is no natural transport mechanism available to move the material directly onshore (toward the shoreline of the US Coast Guard base), and thus erosion predominates in the zone immediately southwest of the west jetty. Farther west along the Cape May City shoreline, erosion rates were found to be substantially lower than in the Coast Guard area, presumably because some of the longshore drift diverted past the inlet jetties is transported farther inshore and becomes available to the beach and nearshore system.

D-16. Cape May Inlet to Lower Township, New Jersey, Phase I General Design Memorandum. This memorandum was completed by the USAED, Philadelphia, in August 1980. Appendix 4 of this memorandum, entitled "Engineering Investigations, Design and Cost Estimates," presents the findings of a shore processes analysis performed by CERC for the Cape May Inlet and vicinity study area. The CERC analysis reviewed previous efforts to calculate longshore transport rates and to identify pertinent physical processes affecting littoral sediment transport. The results of the March 1951 USAED, Philadelphia, report (described in Section D-15) were presented along with a summary of transport rates derived by CERC in 1963 and 1968. This work adopted the 200,000 cubic yards per year net southwest transport rate at Cape May Inlet as derived in the 1951 study. The net southwest transport rate was later revised to 250,000 cubic yards per year. This value represented the difference between a southwest transport component of 500,00 cubic yards annually and a northeast component of 250,000 cubic yards annually. The work performed by CERC for the Phase I GDM (1980) (USAED, Philadelphia 1980) adopted these later values as the best representation of regional long-term transport rates for the study area.

a. Aerial Photo Analysis. The CERC study also used an annual aerial photographic database covering the 1949 to 1978 period to provide greater detail on the sediment budget of individual reaches of the study area. On each of the aerial photographic flights, the shoreline location was determined at each of 68 profile lines from the Hereford Inlet shoreline of Wildwood southwest to Cape May Point. The time-history of shoreline locations was used to derive a mean annual shoreline change rate over the 29-year period of record for each profile line. The linear shoreline change rates were assumed to apply over an active profile extending out to -30 feet (mlw) in order to estimate volume change rates. Table D-7 summarizes the volume change rates derived for the shoreline reaches most pertinent to sand bypassing at Cape May Inlet.

Table D-7

Summary of Volume Change Rates

| CERC Report Reach No. | Location | Annual Volumetric Change, cy |
|---|---|---|
| 4 | Three-mile long segment northeast of Cape May Inlet | +72,000 |
| 5 | USCG* area west of Cape May Inlet | -170,000 |
| 6 | Wilmington Ave to Stockton Place Cape May City | -10,000 |
| 7 | Stockton Plaza to Third Avenue Cape May City | +29,000 |

* US Coast Guard.

b. Results. The principal features of the sediment budget derived by CERC for the shorelines adjacent to Cape May Inlet include the following:

(1) An assumed net southwest transport rate of 250,000 cubic yards per year.

(2) The accretion of 72,000 cubic yards per year on the 3-mile-long reach immediately updrift of the inlet.

(3) The diversion of about 200,000 cubic yards per year of the net annual transport either offshore of the inlet entrance or into the inlet as shoal material.

(4) The annual erosion of 180,000 cubic yards immediately downdrift of the inlet, with 170,000 yards attributable to the US Coast Guard (USCG) Base and the balance to the eastern portion of the Cape May City shoreline.

(5) The annual accretion of 29,000 cubic yards along the western portion of the Cape May City shoreline.

Based on these findings regarding the sediment transport environment of the study area shoreline, it was concluded that a sand bypassing plant that intercepts an average of 180,000 cubic yards per year from the zone updrift of Cape May Inlet would be capable of offsetting the erosion losses occurring in the USCG and Cape May City reaches downdrift of Cape May Inlet.

D-17. Cape May Inlet to Lower Township, New Jersey, Phase II General Design Memorandum. This memorandum (USAED, Philadelphia 1983) was completed in June 1983. It presents the results of detailed engineering and design studies for the Cape May Inlet to Lower Township, New Jersey, project. The findings of the Phase I GDM relative to coastal processes are incorporated into the Phase II GDM.

## Section V. Sand Bypassing Analysis

D-18. General. The analysis of sand bypassing includes an examination of design and cost estimates for sand bypassing using a mobile dredge and a fixed plant with jet pumps. The semimobile jet pump system would consist of a permanent pump house enclosing the various pumping, mechanical, and electrical equipment, jet pump eductors deployed in the fillet area, and a discharge pipeline on the downdrift beach.

D-19. Description of Sand Bypassing by Floating Plant (Dredge). This alternative of sand bypassing with a dredge is the same as the beach nourishment plan recommended in the Phase I and Phase II GDM’s for Cape May Inlet to Lower Township, New Jersey, project. This plan consists of a hydraulic pipeline dredge to pump approximately 360,000 cubic yards every 2 years onto the feeder beach at the USCG Base in Cape May City.

D-20. Description of Sand Bypassing with Fixed Plant. The sand bypass plant investigated for use at Cape May Inlet is a permanent semimobile jet pump system. Sand would be pumped from the fillet area on the northeast side of the inlet through a pipeline under the inlet to the downdrift beach west of the inlet. This system would provide beach nourishment to the beaches southwest of the inlet.

a. Pumphouse. The pumphouse would be a reinforced masonry building approximately 40 feet wide by 50 feet long with a reinforced, concrete floor slab and timber truss roof. Timber piles would be placed below the large eductor water supply pump and the dredge booster pump for adequate support during operations. A control room would be provided for operating personnel to monitor the pumping and make adjustments as necessary.

b. Jet Pumps. The jet pumps would be deployed in the subaqueous zone of the fillet to be capable of dredging the required sand volumes. Flexible hosing would be attached to the eductor to allow for both vertical and horizontal displacement. This mobility increases the reservoir of sand available to the eductor system. Movement of the eductor from one location to another could be accomplished by small boat or land-based equipment such as a tractor or crane.

c. Discharge Line. The discharge pipeline would be buried belowgrade and extend a total distance of approximately 7,300 feet from the pumphouse to the USCG beach on the southwest side of the inlet. The pipeline would cross the inlet along the bottom and extend down the southwest beach 4,500 feet. Four discharge points would be located on the discharge pipeline at points 1,200, 1,900, 3,000, and 4,500 feet, respectively, southwest of the jetty. Each discharge point would be valved for separate and independent operation.

d. Access Road. A paved access road approximately 2,700 feet long with two 9-foot-wide lanes would be provided along an existing off-road vehicle trail. A paved parking area would also be provided at the pumphouse.

D-21. <u>Cost Estimate</u>. Tables D-8 through D-11 show cost estimates for a sand bypass plant with a pumping capacity of 400 cubic yards per hour and sand bypassing by floating plant (dredge). The estimates reflect April 1987 price levels.

## Section VI. Comparison of Alternative Plans

D-22. <u>General</u>. Two plans for sand bypassing were considered in this study. Each plan was based on an average annual rate of sand bypassing of 180,000 cubic yards per year. These plans include sand bypassing with a 400 cubic yards per hour capacity, fixed jet pump system, and sand bypassing by floating plant (dredge). Both plans could bypass the needed quantities of sand westerly to downdrift beaches, if the input sand supply is available. These plans could also reduce maintenance dredging requirements of Cape May Inlet Harbor and result in lower average annual cost.

D-23. <u>Cost Comparison</u>. Table D-12 shows a comparison between the cost of the two sand bypassing options. The average annual cost of sand bypassing with a fixed plant ($747,000) is less than that with a floating dredge system ($1,053,000).

D-24. <u>Advantages of Floating Dredge System</u>. However, the floating dredge plant offers a number of advantages for bypassing sand across the inlet, despite the relatively lower costs associated with the fixed bypassing alternatives. The principal advantage of the floating dredge plant is its

Table D-8

Initial Construction Cost for a Sand Bypass System Using
Jet Pumps, 400 Cubic Yards per Hour Rate

| Description | Unit Price | | Cost |
|---|---|---|---|
| Mobilization and demobilization | L.S. | | $ 40,000 |
| Pump house | L.S. | | 200,000 |
| Mechanical/electrical equipment | L.S. | | 650,000 |
| Eductor and Discharge piping | L.S. | | 1,200,000 |
| Access road | L.S. | | 340,000 |
| | | Subtotal | $2,430,000 |
| | | Contingency (25%) | 607,500 |
| | | Subtotal | $3,037,500 |
| | | E&D @ (15%) | 455,600 |
| | | S&A @ (10%) | 303,800 |
| | | Total | $3,796,900 |
| | | Rounded Total | $3,800,000 |

mobility as compared with the fixed plant. This mobility would be an important factor in the successful operation of a sand bypassing system adjacent to Cape May Inlet because of the potential width (shore-normal) of the zone of active longshore transport and thickness of the sand layer that overlays unsuitable sediments. First, there is a finite but unquantified component of the total longshore sediment flux which is driven by tidal circulation. The tidal component represents a significant factor in the total longshore transport environment, in addition to the transport component related to incident wave energy. If sediment transport in the vicinity of Cape May Inlet were predominantly driven by wave energy, the transport would occur in a zone essentially confined between the shoreline and the breaker line at any given time. In reality at Cape May Inlet, sediment transport occurs over the zone affected by the tidal influence of Delaware Bay and the resultant reversing nearshore currents. The width of this zone is greater than the width of the shoreline-to-breaker zone under practically all conditions experienced in the

Table D-9

Annual Operation and Maintenance Costs for a Sand Bypass System Using Jet Pumps, 400 Cubic Yards per Hour Rate

| Description | | Cost |
|---|---|---|
| Operating crew | | $100,000 |
| Building and equipment maintenance | | 33,000 |
| Materials and supplies | | 10,000 |
| Vehicles | | 4,000 |
| Utilities | | 100,000 |
| Periodic inspection | | 6,000 |
| | Subtotal | $253,000 |
| | 25% Contingency | 63,300 |
| | Subtotal | $316,300 |
| | E&D | 20,000 |
| | S&A | 14,000 |
| | Total | $350,300 |
| | Rounded Total | $350,000* |

* Cost associated with:
Operations $ 217,000
Maintenance $ 133,000

Table D-10

Cost Summary for a 400 Cubic Yards per Hour Jet Pump Plant

| Year | Cost* | Item |
|---|---|---|
| 0 | $3,800,000 | Initial construction |
| 12 | 375,000 | Pump replacement |
| 25 | 3,800,000 | Plant replacement |
| 37 | 375,000 | Pump replacement |
| Every year | 350,000 | Annual operation and maintenance |

* Average annual costs are shown in Table D-12.

Table D-11

Sand Bypass System Using Floating Plant (Dredge)
at 360,000 Cubic Yards Every 2 Years

| Description | | Cost* |
|---|---|---|
| Mobilization and demobilization, L.S. | | $ 250,000 |
| Dredge (27-inch pipeline), 360,000 cy, $4.20 | | $1,512,000 |
| | Subtotal | $1,762,000 |
| | 12% Contingency | $ 211,400 |
| | Subtotal | $1,973,400 |
| | E&D @ 5% | 98,670 |
| | S&A @ 5.53% | 109,130 |
| | Total | $ 2,181,200 |
| | Rounded Total | $ 2,200,000 |

* Average annual costs are shown in Table D-12.

Table D-12

Sand Bypassing Options for Periodic Nourishment

| Parameter | Fixed Bypass Plant 400 cy/hr | Floating Dredge Bypass System |
|---|---|---|
| Initial cost | $3,800,000 | -- |
| Periodic nourishment | $350,000 | $2,200,000 |
| Average annual cost* | $747,000 | $1,053,000 |
| Bypass quantity | 180,000 cy/yr | 360,000 cy every 2 years |

* Based on April 1987 price levels using an 8-7/8-percent discount rate over 50-year project life.

study area. This situation is shown schematically in Figures D-7 and D-9. Secondly, there is presently an uncertainty regarding the thickness of the sand layer overlaying unsuitable (i.e. fine-grained) sediments on the east jetty fillet area. The relative lack of mobility of the fixed plant as compared with the floating dredge alternative presents a potential problem in obtaining the required sediment volume if the depth of excavation is limited by unsuitable subsurface strata. The floating dredge can accommodate such possibilities by obtaining sediment from a larger surface area.

D-25. Additional Considerations. Following completion of the original jetty construction in 1911, the updrift jetty fillet accreted an estimated 100,000 cubic yards per year for several years. As the fillet increased in size, the volumetric rate of accretion decreased to a reported 32,000 cubic yards per year over the period 1927 to 1948. The decrease in rate of accretion is attributable to the fillet area attaining an approximate equilibrium configuration, and may not be due to a decrease in either the net or gross transport rates. The approximate long-term equilibrium which has been attained in the fillet area since about 1948 indicates that the net transport of 250,000 cubic yards per year passes through but does not accumulate in the fillet area. The majority of this material is probably deflected seaward from the northeast jetty and fillet area, although the inlet shoaling analysis indicates that at least 11,000 cubic yards per year are trapped in the inlet entrance. Therefore, the selected alternative for sand bypassing at Cape May Inlet is the mobile dredge alternative, with its ability to cover a larger area than a fixed plant to obtain sediment for bypassing. The floating dredge will serve as a mobile bypassing plant with a periodic operating schedule (every 2 years). The fillet dredging site dictates a storage mode of operation.

D-26. Considerations for Using a Floating Dredge in the Nearshore Zone.

a. Operational Considerations. Although modifications to conventional dredge operation will be necessary, area dredging contractors have responded positively to the proposed Cape May Inlet bypassing plan. Two stipulations have been placed on nearshore dredge operation: that there be a nearby escape route to protected waters and that the dredge be operated in a minimum 20-foot water depth to prevent grounding the vessel. Because of the close proximity of Cape May Harbor to the dredge site, sheltered waters are close by. Also, plans are to begin dredging at the 20-foot contour and work shoreward.

b. Wave Height Limitations. Conventional dredging equipment operating time is limited by wave heights. Compiling wave data, as shown in Chapter 4, Figure 4-2, may be useful in considering a bypassing plan similar to the proposed Cape May Inlet plan.

## Section VII. Summary and Conclusions

D-27. General. All benefit categories applicable to this study were developed in the Phase I and Phase II GDM’s for the Cape May Inlet to Lower Township Project. This study will recalculate navigation benefits for reduced maintenance dredging of the authorized Federal navigation project in order to develop the appropriate share of costs related to existing navigation project savings. The recalculated navigation benefits are based on a detailed

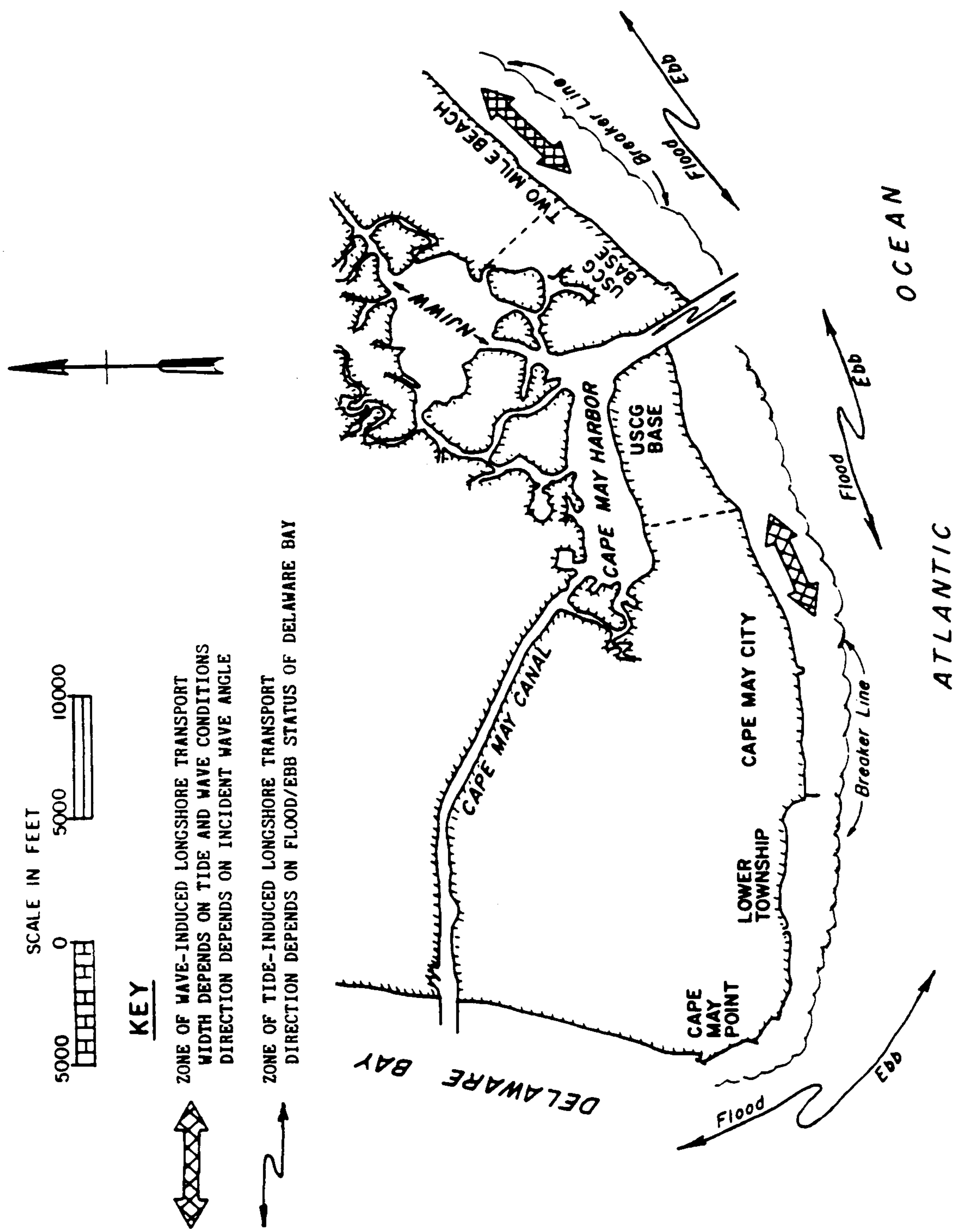


Figure D-9. Schematic of sediment transport processes at Cape May, New Jersey analysis of maintenance dredging of Cape May Inlet (see Section D-6, "Maintenance Dredging Analysis"). (It should be noted that the beach erosion control benefits for the entire Cape May Inlet to Lower Township Project are currently being reevaluated.)

a. Estimation of Reduced Maintenance Benefits. To maximize the benefit for reduced maintenance dredging cost, it was assumed that sand bypassing at Cape May Inlet would reduce inlet shoaling from 11,000 cubic yards per year to zero. Also shoaling in the eastern section of the harbor is assumed to be reduced by 3,000 cubic yards per year. However, annual harbor shoaling of 18,000 cubic yards of silt and clay would continue in the west end of the harbor, as will 3,000 cubic yards of silt and clay in the east end of the harbor. These figures were used to develop the annual maintenance dredging costs for the Cape May Inlet and Harbor Navigation Project and were also used to recalculate this benefit. Implementation of a sand bypassing system at Cape May Inlet will reduce the cost of maintaining the existing Federal navigation project. It is estimated that the sand bypassing system could reduce current maintenance dredging requirements within the Inlet and in Cape May Harbor by a maximum of 100 and 12-1/2 percent, respectively.

b. Cost Comparison. Table D-13 shows a comparison of the cost and maintenance dredging requirements between the Federal project with and without a sand bypass system. The average annual cost of the Federal navigation project without sand bypassing would be approximately $514,000. This cost would be reduced to approximately $392,000 if sand bypassing were implemented, representing a maximum savings or benefit of $122,000.

Table D-13

Federal Navigation Project Dredging Costs With and Without Sand Bypassing (April 1987 Price Levels)

| Scenario | Average Annual Cost | Dredging Qualities |
|---|---|---|
| Federal project w/o sand bypassing | $514,000 | Inlet--22,000 cy<br>Harbor--48,000 cy<br>2-year dredging cycle |
| Federal project with a sand bypassing system | $392,000 | No inlet dredging<br>Harbor 42,000<br>2-year dredging |
| Cost savings | $122,000<br>(24%) | -- |

D-28. Bypassing Plan. The average annual cost of a fixed sand bypass plant is less than that of a floating dredge. Because of its mobility, a floating dredge is not dependent on littoral processes to deliver sand to a fixed location. Uncertainty of available sand from the littoral processes for bypassing to downdrift beaches leads to technical uncertainties and questionable effectiveness of a fixed plant. Therefore, it is concluded that a floating dredge is the most functional alternative for sand bypassing because of mobility and higher probability of sand availability. This plan would consist of bypassing approximately 360,000 cubic yards every 2 years from an area northeast of Cape May Inlet to a feeder beach located at the Coast Guard Training Center. This option is the same as recommended in the Phases I and II GDM's for the Cape May Inlet to Lower Township Project.